METHODS AND SYSTEMS FOR MANAGEMENT AND CONTROL OF AN AUTOMATION CONTROL MODULE

BACKGROUND OF THE INVENTION

[0001] This invention relates generally to automation control modules (ACMs) and more particularly to management and control of ACMs.

[0002] Immediate notification is desired when certain critical events occur in a control system. For example, an ACM may be monitoring the dimensions on a part as part of an inspection process. If the dimensions trend toward becoming too large or too small, the ACM can detect these dimension errors, however, it must timely inform a user so that corrective action is taken. Known ACM systems do not provide timely notification of critical events. Furthermore, known methods and systems for automating and monitoring ACM data collection or control, responding to ACM notifications, and permitting inter-ACM communications and are not timely or standardized. Accordingly, normal operation of known ACM systems can be difficult and time-consuming, thereby increasing development and maintenance of the ACM system software.

BRIEF DESCRIPTION OF THE INVENTION

[0003] In one aspect, an e-mail enabled automation control module (ACM) is provided that comprises an ACM and an e-mail subsystem electrically connected to the ACM. The e-mail subsystem is configured to perform at least one of sending e-mail messages from the ACM through a network, and receiving e-mail messages from the network.

[0004] In another aspect, a method is provided for management and control of an automation control module (ACM). The ACM includes an e-mail subsystem electrically connected to the ACM and a network. The method includes sending e-mail messages from the ACM through a network using the e-mail

subsystem, and receiving e-mail messages from the network using the e-mail subsystem.

[0005] In another aspect, a method is provided for management and control of an automation control module (ACM) using an ACM system. The ACM system includes an ACM, a network, a general purpose computer electrically connected to the network, and an e-mail subsystem electrically connected to the ACM and the network. The method includes sending e-mail messages from the ACM through the network to the general purpose computer using the e-mail subsystem, and receiving e-mail messages from the general purpose computer through the network using the e-mail subsystem.

[0006] In yet a further aspect, an automation control module (ACM) system is provided. The system includes an ACM, a network, a general purpose computer electrically connected to the network, and an e-mail subsystem electrically connected to the ACM and the network. The e-mail subsystem is configured to perform at least one of sending e-mail messages from the ACM through the network to the general purpose computer, and receiving e-mail messages from the general purpose computer through the network.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] Figure 1 is a block diagram illustrating one embodiment of an ACM system of the present invention.

[0008] Figure 2 is a flow chart illustrating one embodiment of a method for management and control of an automation control module using an ACM system.

[0009] Figure 3 is a flow chart illustrating another embodiment of a method for management and control of an automation control module using an ACM system.

[0010] Figure 4 is an example of an e-mail message requesting ACM data from an ACM CPU, and an e-mail message responding to the e-mail message requesting ACM data.

[0011] Figure 5 is an example of an e-mail message registering for ACM notification.

[0012] Figure 6 is an example of an e-mail message notification response to an e-mail message registering for ACM notification.

[0013] Figure 7 is an example of an e-mail message for inter-ACM or device communication, and an e-mail message responding to the e-mail message for inter-ACM or device communication.

[0014] Figure 8 is an example of an e-mail message registering an ACM for ACM notifications from another ACM, and an e-mail message containing ACM notifications from the other ACM.

[0015] Figure 9 is an example of an e-mail message that de-registers an ACM from ACM notifications from another ACM.

DETAILED DESCRIPTION OF THE INVENTION

[0016] Set forth below are descriptions of embodiments of methods and systems for control and management of an ACM. The methods and systems facilitate standard and timely methods for automating ACM data collection and control, notification of important ACM events, and inter-ACM communications and system diagnostics.

[0017] The methods and systems are not limited to the specific embodiments described herein. In addition, components of each system and steps of each method can be practiced independent and separate from other components and steps described herein. Each component and step can also be used in combination with other components and steps.

[0018] As used herein, the term ACM refers to any device that is used to control the automation of an activity, including but not limited to PLCs, computer numeric controls (CNCs), motion control products, home automation products, and commercial automation products, for example controls for automated teller machines or car wash systems. As used herein, ACM data includes different types of data within an ACM system 10 that control operation of ACM system 10. ACM data includes, but is not limited to, user logic programs, user program memory, ACM status and statistics, ACM faults, setting ACM operating states, setting privilege levels, and any other useful ACM information. As used herein, ACM notifications represent various event notifications that include, but are not limited to, change of digital input, output or internal memory states, crossing threshold for analog input, output or internal memory values, change in ACM state (run, stop, etc.), entry in fault table based on severity, fault table threshold detection and any other useful event that may require either customer or programmatic timely response.

[0019] Figure 1 illustrates, in block diagram form, hardware architectures that can be utilized in conjunction with an ACM management and control system. Of course, the system can be implemented on many different platforms and utilize different architectures. The architecture illustrated in Figure 1 is exemplary only.

[0020] Figure 1 is a block diagram illustrating one embodiment of ACM system 10. System 10 includes an e-mail enabled ACM 12, an e-mail subsystem 14, and a general purpose computer 16. ACM 12 includes an ACM CPU 18 that carries out ACM functions, for example user logic and function block executions, input/output (I/O) scanning, and communications to other devices. ACM CPU 18 includes an CPU system memory 20 electrically connected to CPU 18 and, in one embodiment, contains both the operating system (not shown) for ACM CPU 18 and a user's program and data. In one embodiment, an ACM I/O backplane interface 22 is connected to ACM CPU 18, and provides an interface between ACM CPU 18 and an ACM backplane 24 connected to interface 22. ACM backplane 24 provides a physical and electrical means for connecting various I/O or other input modules 26,

for example communications or motion modules, into ACM 12. ACM backplane 24 facilitates the exchange of data between modules 26 and ACM CPU 18. In one embodiment, one or more modules 26 provide an interface for real world inputs (not shown), such as limit or proximity switch status, position of an object, temperature, or pressure, to ACM CPU 18 as parameters for logic or function block execution. In another embodiment, one or more modules 26 provide an interface to real world outputs (not shown) as commanded by ACM CPU 18 to control output devices (not shown), such as actuators, contactors, or solenoids.

[0021] General purpose computer 16 is electrically connected to a network 28, and sends e-mail messages to, and receives e-mail messages from, ACM 12. Network 28 provides the physical medium and intermediate devices (not shown), such as routers, and switches, that connect general purpose computer 16 and other devices 30 to ACM 12. In one embodiment, other devices 30 include one or more ACMs configured to send e-mail messages to, or receive e-mail messages from, ACM 12. In another embodiment, other devices 30 include one or more e-mail-enabled devices. E-mail messages may include ACM data, ACM notifications, and/or standard e-mail elements. For example, in one embodiment, specific command elements in the body of the e-mail instruct an e-mail server 38 to carry out specific actions such as transferring ACM data to ACM CPU 18, reading ACM data from ACM CPU 18, or registering with ACM 12 for notification when particular events or any other useful ACM action occurs. In one embodiment, network 28 is a wide area network (WAN), such as the Internet. In an alternative embodiment, network 28 is a local area network (LAN), such as an Intranet. A user 32 dials or directly logs on to an Intranet or the Internet to gain access to ACM 12. In one embodiment, general purpose computer 16 includes a web browser, and ACM 12 is accessible to general computer 16 via the Internet. General computer 16 is interconnected to the Internet through many interfaces including a different network (not shown), such as a WAN or a LAN, dial in connections, cable modems and special high-speed ISDN lines. General computer 16 is any device capable of interconnecting to the Internet, including a web-based telephone or other web-based connectable equipment.

[0022] E-mail subsystem 14 is electrically coupled to ACM CPU 18, CPU system memory 20, and network 28. E-mail subsystem 14 is shown in Figure 1 to be embedded within ACM 12. In an alternative embodiment, e-mail subsystem 14 is contained in a separate module connected to backplane 24. E-mail subsystem 14 includes a network interface 34 that provides the lower level protocols (TCP/IP) and physical hardware connections to network 28. In one embodiment, e-mail subsystem 14 includes an e-mail client 36 that provides an interface to ACM 12 for ACM CPU 18 to send e-mail to general purpose computer 16 and other devices 30. E-mail client 36 is electrically connected to network interface 34 and ACM 12. E-mail client 36 builds an e-mail message and carries out the proper e-mail transport protocol to deliver the e-mail messages through network interface 34 and network 28 to general computer 16 or devices 30.

[0023] E-mail subsystem 14 includes e-mail server 38, which receives e-mail messages from network interface 34 and maintains one or more mailboxes (not shown) that contain mail messages received from general purpose computer 16 or devices 30, over network 28. In addition, e-mail server 38 parses mail messages for ACM specific functions to transfer ACM data to and from ACM CPU 18 or register devices 30 for notification of ACM events. When an ACM specific function is encountered, e-mail server 38 carries out the ACM specific function. If the function requires ACM data to be returned, e-mail server 38 retrieves the ACM data and transfers the ACM data to e-mail client 36 for delivery to user 32, other ACMs or devices 30, or another requestor. Because e-mail server 38 transfers e-mail messages to and from other ACMs or devices 30, automatic actions occur without user 32 intervention, particularly when there is a supervisory ACM or device 30 that makes overall decisions or collects data for a group of ACMs or devices. The e-mail messages that e-mail server transfers to and from other ACMs or devices 30, in one embodiment, contain ACM data, ACM notifications, a request to register or de-register for notification with another ACM or device 30, or a notification to another ACM or device 30 that has already registered for notification. E-mail server 38 also manages the mailboxes and allows users 32 to access mail messages in the mailboxes.

In one embodiment, e-mail server 38 allows users 32 to read, modify, and delete mail messages in the mailboxes for system diagnostics.

[0024] Figure 2 illustrates one embodiment of a method 50 for management and control of ACM 12 (shown in Figure 1) using ACM system 10 (shown in Figure 1). Method 50 includes sending 52 e-mail messages from ACM 12 through network interface 34 (shown in Figure 1) and network 28 (shown in Figure 1) to general purpose computer 16 (shown in Figure 1), using e-mail client 36 (shown in Figure 1). In one embodiment, e-mail client 36 sends 54 ACM data through network interface 34 and network 28 to general purpose computer 16. In another embodiment, e-mail client 36 sends 56 ACM notifications through network interface 34 and network 28 to general purpose computer 16. E-mail server 38 (shown in Figure 1) receives 58 e-mail messages from general purpose computer 16 through network 28 and network interface 34. E-mail server receives 60 ACM data from general purpose computer 16 through network 28 and network interface 34. In another embodiment, e-mail server receives 62 ACM notifications from general purpose computer 16 through network 28 and network interface 34.

[0025] E-mail server 38 responds 64 to e-mail transfer requests from general purpose computer 16 through network 28 and network interface 34. E-mail server includes at least one mailbox (not shown) and stores 66 e-mail messages in the at least one mailbox. E-mail server 38 grants 68 user 32 (shown in Figure 1) access to the at least one mailbox and allows 70 user 32 to access the at least one mailbox and the e-mail messages stored therein. In one embodiment, e-mail server 38 allows 72 user 32 to read, modify, and delete the e-mail messages stored within the at least one mailbox of e-mail server 38.

[0026] Figure 3 illustrates one embodiment of a method 80 for management and control of ACM 12 (shown in Figure 1) using ACM system 10 (shown in Figure 1). Method 80 includes sending 82 e-mail messages from ACM 12 through network interface 34 (shown in Figure 1) and network 28 (shown in Figure 1) to device 30 (shown in Figure 1), using e-mail client 36 (shown in Figure 1). In one embodiment, e-mail client 36 transfers 84 ACM data from ACM 12 through network

interface 34 and network 28 to device 30. In another embodiment, e-mail client 36 transfers 86 ACM notifications from ACM 12 through network interface 34 and network 28 to device 30. E-mail server 38 (shown in Figure 1) receives 88 e-mail messages from device 30 through network 28 and network interface 34. In one embodiment, e-mail server transfers 90 ACM data from device 30 to ACM 12 through network 28 and network interface 34. In another embodiment, e-mail server transfers 92 ACM notifications from device 30 to ACM 12 through network 28 and network interface 34.

[0027] E-mail server 38 responds 94 to e-mail transfer requests from device 30 through network 28 and network interface 34. E-mail server includes at least one mailbox (not shown) and stores 96 e-mail messages in the at least one mailbox. E-mail server 38 grants 98 device 30 access to the at least one mailbox and allows 100 device 30 to access the at least one mailbox and the e-mail messages stored therein. In one embodiment, e-mail server 38 allows 102 device 30 to read, modify, and delete the e-mail messages stored within the at least one mailbox of e-mail server 38.

[0028] ACM system 10 provides a quick, easy, and standard mechanism for users and other ACMs or network devices to obtain ACM data and ACM notifications from ACM 12. As such, ACM system 10 reduces automation system implementation and maintenance costs by providing easy, standard and timely methods for automating ACM data collection and control, responding to ACM notifications, and facilitating inter-ACM communications.

[0029] Examples

[0030] Figure 4 is an example of an e-mail message 200 requesting ACM data from ACM CPU 18 (shown in Figure 1), and an e-mail message 202 responding to e-mail message 200. A header 204 contains the standard information such as MIME compliance, origin of the message, subject, date, and content type. The body 206 of e-mail message 200 includes a plurality of ACM request functions 208

requesting 10 memory values from CPU system memory 20. E-mail message 202 returns e-mail message 200, but replaces request functions 208 with ACM data 210.

[0031] Figure 5 is an example of an e-mail message 220 registering for ACM notification. E-mail message 220 includes an ACM request function 224 that informs e-mail server 38 (shown in Figure 1) to send an e-mail to the sender of e-mail 220 when a fault table entry (not shown) is added to an ACM 12 (shown in Figure 1) fault table (not shown).

[0032] Figure 6 is an example of an e-mail message 222 notification response to e-mail message 220 (shown in Figure 5). E-mail message 222 returns e-mail message 220, but replaces request functions 224 with ACM data 226.

[0033] Figure 7 is an example of an e-mail message 230 for inter-ACM or device communication, and an e-mail message 232 responding to e-mail message 230. E-mail message 230 includes a plurality of ACM function requests 234. E-mail message 232 returns e-mail message 230. E-mail server 38 (shown in Figure 1) parses e-mail message 232 and sends a request to ACM CPU 18 (shown in Figure 1) to perform the functions requested in function requests 234.

[0034] Figure 8 is an example of an e-mail message 240 registering ACM 12 (shown in Figure 1) for ACM notifications from ACM 30 (shown in Figure 1), and an e-mail message 242 containing ACM notifications 244 from ACM 30.

[0035] Figure 9 is an example of an e-mail message 246 that de-registers ACM 12 (shown in Figure 1) from ACM notifications from ACM 30 (shown in Figure 1).

[0036] While the invention has been described in terms of various specific embodiments, those skilled in the art will recognize that the invention can be practiced with modification within the spirit and scope of the claims.